XXI. *On the Elementary Structure of the Muscular Fibre of Animal and Organic Life.*
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THE volume of the Transactions of the Royal Society for the year 1817 contains a paper which formed the subject of the Croonian Lecture for that year by Sir EVERARD HOME, in which he endeavours to prove the identity of the muscular filaments with the globules of the blood.

To the above paper is appended a plate which exhibits an ultimate muscular filament composed of a string of globules, marked by lateral indentations corresponding to each globule.

It was inferred by Sir EVERARD HOME, from the experiments of Mr. BAUER, which appear to have furnished the material for the paper, that an ultimate muscular filament consists of a string of globules of the blood, estimated by Capt. KATER at the diameter of about the $\frac{1}{3000}$th part of an inch.

This opinion of the composition of muscular fibre, which has been, according to DUTROCHET, confirmed by the authorities of France, viz. BECLARD, EDWARDS, PREVOST, DUMAS, and himself, was first opposed by Messrs. HODGKIN and LISTER, whose researches on the subject were published in the year 1832, in an Appendix to the translation by the former gentleman of Dr. EDWARDS's work, De l'Influence des Agens Physiques sur la Vie.

These authorities were the first to deny the existence of a globular structure, and to assert the uninterrupted continuity of the component parts of the fibre. They proceed to point out a most important distinction " between the minute structures of the muscles of voluntary motion and those of organic life." The former, they assert, " are characterized by innumerable very minute, but clear and fine parallel lines or striæ, which cross the fibre transversely." These they conceive to be the distinguishing feature of true muscle. I shall have occasion again to refer to the valuable though brief observations of Messrs. HODGKIN and LISTER on the subject of the muscular fibre of organic life.

Having had the opportunity afforded me, by the kindness of my friend Mr. HENRY GOADBY, of testing the truth of the opinions of these eminent physiologists by the aid of his admirable microscope, I beg to lay before the Society the results of some inquiries confirmatory of these opinions, and to add some new facts which I hope may be not uninteresting to physiological inquirers.

The microscope which I have employed is an achromatic instrument, possessing a

magnifying power of about 600 diameters, by which the objects are exhibited with remarkable distinctness. In order, however, to accomplish this with the best effect, I have invariably submitted the object to a careful preparation under a smaller microscope, used by Mr. GOADBY in his able dissections of the anatomy of insects, on the field of which a minute portion of perfectly recent muscle is placed, which has been detached from the mass by means of a lancet, or a fine pair of curved scissars. This, placed on a slip of glass and immersed in water, is observed to consist of many small fasciculi, which may be separated from each other by two pairs of delicate forceps. Of these fasciculi one may be retained, and laid out on the glass with as little violence done to its natural structure as possible.

The connecting medium of the whole of the fasciculi, is a finely reticulated cellular tissue, the tenacity of which is *great* in proportion as the muscle is *fresh*; but it may be at all times divided with scissars without injury either to the form, or to the arrangement of the layer of fibres to be submitted to examination with the larger microscope.

The residue reduced by dissection to a nearly diaphanous state will consist of a single layer of ultimate muscular *fibres*; and of these the object thus prepared may contain from twenty to thirty placed parallel to each other, occupying for the most part the same plane, and straight in direction.

In obedience to the recommendation of PROSCHASKA, and indeed of most physiologists who have made muscular fibre the subject of minute examination, I have subjected the objects I have employed, to boiling and maceration. The result of which has been an increased conviction of the superiority of the perfectly recent fibre. The effect of boiling is that of softening to a considerable degree the cellular tissue, which breaks down readily under the instrument employed, and consequently, the easy separation of the fibres from each other. This I conceive to be a positive objection, inasmuch as a large quantity of cellular tissue retains its connection to the individual fibres, from which, in consequence of its unnatural softness, it cannot be disengaged. Each fibre therefore presents a woolly appearance, and is comparatively indistinct; whereas by the aid of the dissecting microscope, with a little careful manipulation, all the superfluous cellular tissue may be removed from the recent fibre that has not been subjected to this process, in consequence of its unimpaired tenuity of texture, and the fibre exhibits in a very striking degree its natural characters.

Nor could I concur in the recommendation of PROSCHASKA: " Tum lacertus inter duos digitos teritur leniter ac premitur donec mollis et pulposus quasi evadat lacertus." On the contrary, I believe the less violence of any kind employed the better. By a coarse manipulation the fibres may be rendered zigzag or serpentine, but their natural direction I believe to be straight.

Each fibre is connected with its fellow by cellular membrane still finer than that which connects the smaller fasciculi, and so transparent when recent, as not to impair the distinct view of the fibre itself when clearly in focus. If this cellular connection be lacerated, the fibres are drawn asunder and become distorted.

The muscular fibres of animal life, possess a very varying diameter, but their average size, and that which largely predominates, may be stated at about $\frac{1}{400}$th of an inch; but they may be found of all magnitudes, from the $\frac{1}{250}$th to the $\frac{1}{700}$th of an inch. If the object be separated from the mass with a pair of scissars, the extremities of many of the fibres will be compressed and closed, but they retain their natural diameters up to the extremity, if separated with a lancet or knife; this therefore is preferable.

When the object is clearly in focus circular striæ are exposed, crossing the fibre along its whole length (Plate XVII. fig. 1. *a.*). These were known to and delineated by LEUWENHOEK, MUYS, PROSCHASKA, FONTANA, and others. By the former eminent physiologist they were delineated but coarsely, and as existing at irregular intervals from each other; and judging from the plate by PROSCHASKA, they were but imperfectly known to him; yet he has devoted a large portion of one entire chapter to their description. FONTANA's work, however, " Sur les Poisons," contains a beautiful representation of the transverse striæ, which both for correctness and for effect cannot well be surpassed. They are seen more or less distinctly in the fibre of animal life in all the examples I have examined, but most distinctly in that of the Ox, the Hog, the Ichneumon Fly, and the *Blatta Americana* (Cockroach). In the two latter they form prominent and elevated bands, resembling in their magnified form the rings of the human trachea (fig. 2. *a b.*). STRAUS states that the muscular fibre of the *Melolontha vulgaris* (Cockchafer) is similarly serrated.

The transverse striæ are placed closely together, but varying much in thickness and in number, a portion of the length of the fibre equal to its diameter containing from 16 to 25. They sometimes appear uninterrupted in their course across the fibre, and occasionally exhibit the appearance of shorter interrupted lines, which, surrounding it, present the aspect of a cylinder of a polygonal form (fig. 1. *b.*). In the plate of FONTANA the striæ are represented of each variety in the same object.

I believe this appearance, which is both frequent and regular, to arise from violence to the fibre, and to be neither natural to its structure nor dependent on optical deception. This arrangement has given rise to the opinion by PROSCHASKA, that the muscular fibres were polyhedral cylinders. It must be observed, however, that this is not an uniform appearance, but that the transverse striæ are more generally arranged in continuous and uninterrupted circular lines around each ultimate fibre. I have remarked that if great care be taken in the preparation of the object while under the dissecting microscope, this broken arrangement is rarely visible; and considering the improbability of the co-existence in the *living fibre* of both the series described, as inconsistent with the simplicity of nature, and the impossibility of converting by any manipulation the *in*terrupted into the continuous and *un*interrupted striæ, I cannot doubt but that this apparently angular arrangement is due to so many artificial depressions of a mutilated *fibre*.

The regularity of the appearance I conceive to be produced by the connection

which subsists between the circular striæ and the longitudinal filaments beneath them, the latter being connected together in bands around the tube of the fibre, each band containing about eight or ten filaments, and the appearance of an angular arrangement of the striæ is produced by the partial separation of these portions of the fibre from each other. The uniformity of this separation, of which each fibre is susceptible, appears to warrant its subdivision into these bands, which I propose to name " *Fibrillæ,*" these again being subdivided into "*filaments.*"

If a fibre be partly unravelled, this irregular and interrupted appearance of the striæ will be rendered still more apparent (fig. 3.).

Of the anatomists whose names I have mentioned, PROSCHASKA has given the most minute description of the transverse striæ, and yet judging from the plates attached to his work, " De Carne Musculari," he must either have seen them with imperfect microscopic powers, or the delineations by the artist have done injustice to his descriptions.

It is, perhaps, somewhat remarkable that the striæ are not seen with equal distinctness, in all the muscular fibre of animal life. When distinct, they present themselves in the form of well-defined rings, the extremities of which may be distinctly traced, encircling the fibre equidistant from each other, uniform in diameter, and apparently elevated from its surface into ridges, leaving depressions between them ; and when a fibre is sufficiently bent to render its convex edge somewhat tense, they very apparently stand out from the plane of the fibres, forming circular ridges around it, and presenting the appearance of a fine serrated edge. When very large they occasionally form distinct bifurcations or loops, but pursue their course with the utmost regularity.

Although the striæ exhibit the character above described, of elevated rings crossing the fibre, they present in different examples some variety in appearance. For the most part the dark lines are narrower than the light which alternate with them. Sometimes the dark appear elevated, the light or colourless striæ forming the depressions. At other times this appearance is reversed, and the elevated striæ appear to be formed by the *intervals between the darker lines.*

It is not easy to determine the question by tracing these to the margins of the fibre, because the entire fibre is not in focus at the same time, and the slightest movement of the field of the microscope distracts the eye from the point of observation. After adopting various modes of inquiry which led to no satisfactory conclusion, accident ultimately convinced me that the opinion I at first entertained was erroneous. I obtained a fibre, torn in the longitudinal direction, in which it was evident that the lines of separation corresponded uniformly with the dark striæ, the light, although distorted from their straight direction, remaining unbroken, and pursuing a distinctly continuous course across the fibre (See Plate XIX. fig. 5.).

I infer, therefore, that the light are the *elevated* striæ, and the dark intervening lines, the depressions. After five years immersion in spirit I find them as distinct

and well defined as in the recent fibre, and I am informed by Mr. OWEN that they remain perfectly unaltered in muscular fibre that has been immersed in spirit since the period of Mr. HUNTER.

With respect to their use PROSCHASKA says, "Nil aliud sunt quam profundiora vestigia a vasis, nervis et filis cellulosis, fibram circumdantibus, et ejus vaginam perreptantibus impressa," and FONTANA adopts this opinion of PROSCHASKA, while the plates of the two authors bear but a very remote resemblance to each other.

I conceive the arrangement of the transverse striæ to be much too uniform to warrant the explanation of PROSCHASKA and FONTANA, for they are not grooves but positive elevations on the fibre. Nor are they invariably found on the muscular fibre of animal life, of which according to the views of PROSCHASKA and FONTANA they ought to be the invariable attendants, and with one exception never on that of organic life; besides which, as I shall afterwards endeavour to prove, they are three or four times smaller than the globules of the blood themselves, and consequently cannot be destined to the transmission of blood vessels. They appear to hold some relation rather to the integrity of the fibre.

In the Pharynx the size of the fibres varies from the $\frac{1}{700}$th to the $\frac{1}{300}$th of an inch in diameter, and here is exhibited the greatest variety in the circular striæ. They are invariably large as the fibre is small, while the broader fibres, exceeding greatly the average diameter of $\frac{1}{400}$ of an inch, exhibit the most delicate pencilling and as minute as the eye can detect. I have once observed them varying in size on the same fibre (Plate XVII. fig. 4.).

Is it probable, therefore, that they are destined to the purpose of conveying vessels or nerves, or that they are mere cellular threads? Throughout the general system of animal life, and except in the Pharynx, the circular striæ are most prominent in the large and well-formed fibre, the completeness and integrity of which is its most characteristic feature.

If a portion of muscle, which has degenerated by disease and consequent inaction, be submitted to observation, it will exhibit the outline of the fibres *without any trace* of the striæ or longitudinal filaments; little, indeed, remains beyond the mere form of the fibre. I have examined the gastrocnemeus and soleus muscle of a person for many years bedridden, in which these muscles were wasted to a whitish mass, little exceeding in diameter that of their own tendons.

The striæ appear to bind together the united strands of the fibre, retaining them in position around the cylinder; they are the woof to the warp of the longitudinal filaments, but instead of being interlaced with them they form circles around, and attached to the most prominent part of the longitudinal filaments to which they are intimately united.

The Filaments or Longitudinal Striæ.

I have retained the name of *fibre* to that division of a fasciculus, which though extremely minute, is apparent to ordinary vision.

But each fibre is a compound structure, and is surrounded externally by the circular striæ I have above described. A fibre may be reduced to its apparent elements by a successful manipulation, which will exhibit its ultimate structure, composed of a series of longitudinal lines or *filaments*, placed parallel and in close apposition to each other, around the axis of the tube of the fibre. These are the ultimate known filaments of muscular texture, and of which each fibre of the diameter of $\frac{1}{400}$th of an inch contains from 90 to 100.

They may occasionally be separated from each other, forming a sort of tasselled or brush-like extremity of the fibre they compose. Their diameter I conceive to be about the $\frac{1}{10000}$th part of an inch (Plate XVII. fig. 3. *c c.*).

I have examined these filaments with great care, and with a magnifying power, nearly 200 times greater than that employed by Sir E. HOME and Mr. BAUER, and I am compelled to differ from these gentlemen in favour of the opinion, first promulgated by Messrs. HODGKIN and LISTER, that they are *un*interrupted threads or cylinders, and neither composed of the globules of the blood, nor possessing even a globular arrangement.

I have carefully compared a filament magnified by 600 diameters with the plate by Sir E. HOME in the Transactions of the Society, and I find that neither the human filament nor that of any animal in which I have observed it, is nearly so large nor so distinct as that represented in the above plate. Yet Mr. BAUER's magnifying power was 200 diameters less than that of Mr. GOADBY's which I employed. BECLARD, M. EDWARDS, PREVOST, DUTROCHET, and Dr. GRANT, have adopted this view first promulgated by Sir E. HOME. FONTANA, who has delineated the fibre of muscle so accurately, and who applied a single lens of $\frac{1}{90}$th of an inch focus, asserts them to be cylinders, *hollow* or *solid*, and only occasionally presenting a globular appearance.

It should be particularly observed that the circular striæ which surround each fibre are closely adherent to the most projecting surface of each longitudinal *filament*. These latter, when detached into separate shreds, occasionally exhibit on their surface, the *marks* or *indentations corresponding* to the *distance* between the *circular striæ* on the whole fibre (fig. 3. *d d.*), and I think the filament will present the more or less distinct appearance of a globular structure in proportion to the distinctness of the circular striæ.

In the Haddock and the Cod, the *fibres* of which are very large, and in which the circular striæ are of extreme beauty and delicacy, the ultimate filaments present no appearance of a globular arrangement, but are distinctly continuous and uniform throughout their whole length.

Probably the best test to which they can be submitted is that of placing the globules of the blood and some muscular filaments, under the field of the microscope at the same time. When subjected to this mode of inquiry, the filaments will be observed to be excessively minute, and the globules of the blood may be seen floating between and behind the different *fibres*, in the apparent breadth of about twelve to

a single fibre, and from three to four times larger than the reputed globules of Sir E. HOME and Mr. BAUER (Plate XVII. fig. 5.).

I have counted on making a successful division of a fibre about 100 filaments, the number mentioned by LEUWENHOEK, somewhat less than the half of which were in focus at the same time, those of the opposite side being brought into view, by a new adjustment of the microscope. A single globule suspended behind a separated fibre, would correspond to the breadth of about three filaments.

Now the estimate of the diameter of a globule of blood by Dr. WOLLASTON and Captain KATER is the $\frac{1}{5000}$th part of an inch, from which the above calculation does not materially differ. A more recent admeasurement by M. EDWARDS* gives them a diameter of $\frac{1}{325}$th of a line. A single muscular fibre has a diameter of $\frac{1}{400}$th of an inch. A single globule of blood, which is about the twelfth part of the breadth of a fibre, $\frac{1}{4800}$th of an inch. If each fibre contain 100 filaments, something less than the transverse breadth of the fibre, or forty, or allowing for the receding margins multiplied by 400, is 16000, which is the breadth of a single filament. A globule of blood to the diameter of a filament is therefore as 4800 to 16000. If this calculation make any approach towards truth, the filaments cannot be composed of the globules of the blood, and they are not identical.

I believe the appearance of globules, of which the filaments are asserted to be composed, is due to the delicate indentations of the transverse striæ upon them, for the distinctness of the globular appearance is always proportionate to that of the transverse striæ. I was, therefore, very desirous of examining the appearance in the fibre of an animal characterized by delicacy of the striæ, and I found that in the Cod and the Haddock, in which they are most minute, the filaments being disencumbered of their connection to the cross bands or striæ, pursue their course floating and twisted in all directions, without a trace of a globular appearance or mark of any kind, cylindrical, and of uniform thickness throughout.

Glutinous interior of the fibre.

The interior of each fibre appears to contain a glutinous semitransparent substance, covering thickly the inner surface of the longitudinal filaments. It is very soluble in water, and when the end of a fibre is broken up, exhibiting its filamentous structure, no trace of this substance is seen, but it is apparent on the internal surface of each fibre when the tube is exposed. It is this glutinous coating to the interior of the tube, that conceals from view in a degree the long filaments of the opposite surface, when that part of the fibre is brought into focus.

Tube of the fibre.

The divided extremity of each fibre presents the appearance of a jagged circle terminating an apparently hollow tube. For the most part these extremities are con-

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* Encyclopedia of Anatomy and Physiology.

tracted, and are occasionally elongated even to a point. Frequently, however, the fibre retains its natural diameter up to its termination in the jagged circle (Plate XVII. fig. 1. *c.*). This part of the fibre will occasionally exhibit an orifice, such as would appear by the foreshortening of a tube cut obliquely. When a section of the fibre is made in the vertical direction, this appearance is not observed.

It is difficult to obtain a distinct view of the tubular end of a fibre by any careful preparation of the object, but *without* such preparation several fibres in the same object, may exhibit its tubular character. If such a fibre be brought into focus at its extremity, the circular striæ and longitudinal filaments will be exposed, extending to the *near* margin, and if the depth of the fibre be then *penetrated* by the microscope, the longitudinal filaments of the opposite side will be *first* exposed, and secondly, the circular striæ, but neither of these will be distinct, being obscured by the glutinous lining of the interior of the tube. A careful adjustment will thus detect the aperture of the tube of the fibre, which appears in the form of a hollow cylinder, perfectly translucent in its centre, but less so at its sides from their vertical direction to the plane on which they rest. The latter present when in focus the dark outline of the fibre, extending along its length.

If a single fibre be divided in the *longitudinal* direction its cavity may be exposed along a considerable length, the filaments composing the fibre with their investing striæ of the opposite side of the cylinder may then be seen when the near side is out of focus (Plate XVIII. fig. 1. *a.*).

As the tubular character of muscular fibre is not always distinctly apparent, I would add the following arguments in favour of this view of their composition.

1st. A fibre is frequently elongated to a point, up to the extreme external surface of which, the circular striæ are apparent. If the fibre be a solid cylinder, what becomes of the central substance? for it is evidently the external surface that is so attenuated, indicated by the presence of the circular striæ.

2nd. When a fibre is entirely separated into its filaments forming a fringe-like extremity, that surface of the fibre nearest the eye, forms all that portion of the fringe which is distinctly in focus. If the focus be then changed the fringe of the *opposite* side is brought into view, but there is no middle fringe to complete what would *then* be, a solid tassel (Plate XVII. fig. 3.).

3rd. If a few fibres be placed on glass and dried, little remains apparent, beyond the black outline of each fibre, their central portions become obliterated, and consequently the fibre is transparent. If the margin of the fibres are rendered dark by their perpendicularity to the plane below them, *à fortiori*, the *middle* portion of the fibre ought to exhibit the same phenomenon, for it is higher from the surface and consequently thicker.

4th. The separation of a few or more filaments from the body of a fibre, never exhibits a second layer of filaments beneath them. This view of a central filament might reasonably be expected if each fibre were composed of a solid cylinder; and

it would be interesting to ascertain the relation which subsists between the central filaments, supposing the fibre to possess them, and the transverse striæ.

I have never seen any appearance like that of filaments projecting from the interior of the fibre at its extremity; for although the exhibition of the tubular character may be rare, involving as it does many conditions, yet it is not unreasonable to imagine, that if the fibre were solid, the extremities of the central filaments would be occasionally as apparent, as those which are arranged on its external surface.

5th. Analogy to other structures would enable us in some degree to comprehend the utility of the circular striæ, supposing them to surround a tube which they probably compress in certain states of its action.

Are the *filaments* like the fibres which they compose *tubular*?

Up to a late period of my inquiries into this subject, I had only the ground of analogy to support the opinion of the tubular character of the filaments, but being engaged in examining the muscular coat of the trachea of a Horse, I was not a little gratified to observe the very apparently tubular composition of these threads, one of which, indeed, placed at right angles to the plane below it, exhibited its cavity to some distance within (Plate XVIII. fig. 2.). Indeed the filaments presented very much the aspect of miniature fibres, in which I could almost fancy I saw some traces of still minuter threads. This though speculative is, I think, not very improbable; but of the tubular nature of these delicate threads, I have no doubt; they were distinctly perceptible to many observers.

From the above I deduce,

That the human muscular fibres of animal life possess an average diameter of $\frac{1}{400}$th of an inch.

That they are surrounded by circular striæ varying in thickness and in number.

That the striæ are actual ridges or elevations on the fibre, leaving depressions between them, considerably smaller than the globules of the blood.

That each fibre is divisible into bands or fibrillæ, which, composed of many ultimate filaments are arranged in parallel longitudinal lines around the axis of the fibre, and that the partial separation of these fibrillæ produces the occasional broken or interrupted appearance of the circular striæ.

That each band or fibrilla is subdivided into filaments, of which every fibre of $\frac{1}{400}$th of an inch diameter contains about 100.

That the muscular filaments possess a diameter of about the third part of a globule of the blood, or $\frac{1}{10000}$th of an inch, and that they are tubular, and that these filaments are arranged longitudinally around the tube of the fibre, which finally contains a soluble gluten.

The human fibre of animal life pervades the whole of the external muscles, and all internal muscles connected to any form of tendinous matter. This will include those of the tongue, palate, larynx, and pharynx, with some portion of the œsophagus prolonged from it, and constituting an exception to this rule; the muscles of the orbit

and ear, diaphragm, intercostals, levator and sphincter ani.   The muscles of the tympanum incased in bone, composed so largely of tendinous matter, and apparently beyond the reach of voluntary power, must however be classed among the muscles of animal life.   Yet they are so intermixed with tendon, that had I not rendered myself familiar with the structure and appearance of tendinous fibre, which possesses a remote resemblance to the muscular fibre of organic life, I should have erroneously concluded that they belonged to that class.   They possess, however, all the characters incidental to the fibre of animal life.

<div align="center">ORGANIC LIFE.</div>

The microscopic view of the muscle of organic or involuntary life exhibits a structure essentially different from that of the fibre of the external muscles.

The difference was first made known by Messrs. HODGKIN and LISTER, who state that "the minute fibrillæ which enter into the composition of the fasciculi of fibres of which this tissue is made up, instead of presenting the transverse striæ, are perfectly smooth, and appear to be continued to a considerable length, of nearly uniform width." They describe the fibre as nearly straight and parallel, occasionally interlacing and dividing among themselves.

In the muscular fibre of organic life there are no distinct and separable fibres, no transverse striæ, with one exception, and no appearance of the larger tubes.

This tissue appears to consist of a series of irregularly disposed lines of various thickness, taking for the most part a longitudinal direction, and forming a kind of untraceable net-work difficult of delineation.   Although there exist no single fibres connected by cellular tissue with others around it, yet there is no difficulty in observing the direction of the muscle; for the lines take one course, frequently, however, bending to one side and uniting with others around: but the aggregate, though far from straight, pursue one general longitudinal direction (Plate XVIII. fig. 3.).   The cut margin of the object exhibits no projecting fibres, which in the process of preparation have started out from their connection with others, or which have evaded the straight division with the knife; but the whole edge is smooth and uniform.   The drawing is taken from the fibre of the small intestine (jejunum).

The muscle of organic life appears to possess a smaller proportion of cellular tissue than that of the voluntary muscles.   None is required for the connection of fibres, for in reality there are *no fibres* in the muscle of organic life, which rather consists of filaments interwoven with each other to form the general structure, than arranged in parallel lines around the cylinder of each separate fibre, as observed in the muscular fibre of animal life.

I could imagine it might be artificially imitated by subjecting a thin layer of these latter fibres to a degree of pressure which would destroy the integrity of each fibre, and yet preserve the general direction of its filaments.   It may be readily distinguished from tendinous fibre, in which the filaments are uniform in size, pursuing

individually one unvarying line, each filament being parallel to those around it. This great regularity in arrangement renders tendinous fibre a microscopic object of singular beauty and delicacy, when it has not been subjected to a coarse manipulation (Plate XVIII. fig. 4. *b.*).

To the general description of the muscular fibre of organic life, the heart forms an important exception (Plate XVIII. fig. 5.). It appears to possess a somewhat compound character of texture. There is a nearer approach to the fibres of animal life, each fibre being more distinct than those of any other internal viscus, and possessing a very delicate pencilling of *transverse striæ*, as observed by HODGKIN and LISTER. The fibres are only about one third of the magnitude of the animal fibre of the same subject; they are interwoven with each other, and being more separable than the general fibre of the other organic viscera, project at the cut extremities, where their diameter is very apparent. The net-work which they form is composed of the entire fibre, and not, as in organic life in general, by the filaments of each.

The examination of the pharynx, composed of the fibre of *animal* life, and that of the œsophagus of *organic* life, exhibited some views of considerable interest. This continuous line of tube commences in animal, and ends in organic fibre. I was desirous of ascertaining the nature of the junction, whether by a gradual blending of one description of fibre into the other, or by an admixture of the two.

The constrictor superior, the first agent of deglutition, exhibits the perfect fibre of animal life. The striæ are of ordinary size, of about 24 to the diameter of the fibre.

Those of the constrictor medius exhibit no peculiarity, except that they are strongly marked and distinct; but the cellular tissue is dense, possessing the character of *that* connecting the texture of organic life. The same observations will apply to the constrictor inferior, in which the density of the cellular tissue is yet perhaps greater.

The structure of the first 2 inches and half or 3 inches of the œsophagus is that of animal life, but surrounded with striæ varying much in number and in breadth. The size of the fibres themselves, likewise varies considerably, and may be found from that of the 700th to the 300th of an inch diameter (Plate XIX. fig. 1.). I have generally observed that the *smaller* fibres possessed the *larger* striæ. These frequently appeared to bifurcate in their course around the tube, and at the edge distinctly projected from the surface, forming the serrated appearance I have previously described. The larger the fibre the more delicate are the striæ, which become less and less apparent on the larger fibres, as they descend on the œsophagus. Still the smaller fibre with large striæ may be found as far as the fibre of animal life itself exists, and this junction of the two takes place at about 3 inches from the lower border of the constrictor inferior, where both structures are associated in the same object. One half inch below, and the fibre of animal life ceases entirely, and it is at this precise point that the œsophagus enters the cavity of the chest.

Perhaps the most interesting, as well as the most instructive object exhibiting the muscular structure of organic life, is that of the *arterial system,* the composition of

which has presented material of the deepest interest to all physiologists of the last and the present century.

If a portion of the middle coat of an artery, whether of the pulmonary or aortic system, be submitted for examination, it is impossible to distinguish it from the muscular texture of the stomach, intestinal canal, or bladder. It exhibits the perfect composition of the organic muscular texture of these parts (Plate XIX. fig. 2.).

It would be impracticable to determine, with so large a microscopic power as that which this subject demands, the relative proportions of muscular fibre in the larger, compared with that in the smaller arterial tubes; but I have observed that the muscular texture of the smaller vessels, as the internal mammary and the smaller branches of the iliacs, is paler and of a more delicate fabric, but their *relative* proportions could only be appreciated by a different mode of inquiry.

I need hardly state, perhaps, that the fibres are placed circularly around the vessels, and that the muscular, forms the thickest of the coats of these tubes.

I can discover *no resemblance* between the structure of the middle coat of an artery and that of the elastic ligamentous tissues of the body.

If the drawing of the former be compared with that of the muscular fibre of organic life in general, I think it will be found so closely to correspond as to appear almost identical. Possibly the arterial tissue is more delicate, but both apparent composition and arrangement are the same.

I observe, however, no comparison between the arterial tissue and that of the elastic ligamentous structures. These latter are composed of large and distinct filaments placed in a parallel direction, and connected by dense cellular tissue. Each filament possesses its characteristic property of elasticity, and when separated at one extremity from the mass it curls backwards on itself.

The entire structure is likewise more transparent than the arterial tissue, and is much more simple in its arrangement (Plate XIX. fig. 4.).

I have been unable to detect anything approaching to the character of muscular fibre in the structure of the venous system in general. I have observed it, however, in the hepatic veins of the Seal; and it doubtless exists in all animals subject to an arrest of the venous circulation around the heart.

There yet remains a structure in the economy which presents an interest little inferior to that of the arterial system, I mean the iris.

The tenacity of this membrane is greater than that of any other structure I have examined, so much so, as to render it exceedingly difficult of preparation under the dissecting microscope.

When exhibited with the larger power it presents so much the character of the muscular fibre of organic life, that I feel almost inclined to associate it with that system.

As regards the *arrangement*, I have *less doubt* than I have of the *chemical composition* of the iris, which does not possess the semitransparent character of *fibrine*.

Yet there exist some important distinctions, which require considerably more exten-
sive observation than I have hitherto been able to make; and I am anxious not to
commit myself by the expression of an opinion hastily formed as to its composition,
on which my limited inquiries have hitherto fallen far short of the difficulties of the
subject.

It is difficult to explain the experiments of Sir E. HOME as regards the muscular
texture of the stomach which he employed, and which is of the pure structure of or-
ganic life. I have examined each part, and I have been unable to obtain the least
trace of animal fibre. The ultimate muscular filaments *may* be seen in the texture
of organic, but with by no means the distinctness of animal life, in consequence of
its reticulated structure which renders them difficult of separation from the bulk of
the fibre.

The muscle of organic life pervades the greater part of the œsophagus, the stomach
including that of the *ruminants* and the alimentary canal, the trachea and bronchial
tubes, the *uterus*, the urinary bladder, the arterial system, and possibly the iris.

The diameter of all muscular fibres holds a relation to age, being in the human
fœtus, as well as in the young of all the animals in which I have observed it, about
one third the diameter of that of mature age (Plate XIX. fig. 3.).

On comparing the muscular fibre of animal and organic, or voluntary and invo-
luntary life, it does not appear surprising that there should exist the remarkable va-
riety of structure which I have described. Although both systems are embraced
under the general denomination of *muscle*, and possessing the characteristic property
of irritability, yet their functions in the economy are so distinct, and the power re-
quired by each is so unequal, that we might almost have conceived the existence of
an important difference of structure.

In the muscle of *animal* life we find the fibres with their subordinate filaments pur-
suing a direct course between the attachments of the whole muscle, or deviating
from it merely for the purpose of a convenient adhesion to its common tendon.
Hence the advantage obtained by a united and cooperating force, by which the whole
component fibres of the muscle are called into action at the same time. The fibres
possess no independent influence, but all cooperate to one obvious end, that of ap-
proximating the extremities of the muscle, and act with a force which, considering
the nature of their general adaptation, may well be deemed enormous.

But the power of the muscle of organic life is limited. We find it spread over ex-
tensive tubular surfaces of membrane, and contributing to the involuntary functions
of internal life, by a slow and gradually extending contraction. It has no antagonist
but the contents of the tube it surrounds, its influence on which extends along the
surface of the muscle, as the contents descend within the tube.

By means of its matted structure it serves the purpose of a nearly complete invest-
ment to the canal it surrounds, while its connecting and reticulated composition
enables it at once to transfer the contents of the tube within the influence of the

portion prolonged from it, and to communicate the stimulus necessary to their removal.

To this function the heart again forms a striking exception. Its contractions are impetuous, and throughout each division of the organ simultaneous. In the heart therefore we find the modified but *separate* fibre of animal life, with all the physical characters indicating great contractile power, demanded for the important function it is known to possess.

Charterhouse Square,
   January 10, 1837.

Explanation of the PLATES.

PLATE XVII.

Fig. 1. *a.* An unbroken muscular fibre of animal life, with continuous striæ, magnified about 600 times, linear measurement.
   c. Its tubular extremity.
   b. A similar fibre broken into fibrillæ, exhibiting the interrupted striæ, and presenting a polygonal appearance.

Fig. 2. *a b.* Muscular fibres of animal life, from the Cockchafer.

Fig. 3. A muscular fibre separated at its extremity into its component filaments.
   a, a, a. Striæ continuous across the unbroken fibre.
   b, b. The fibre broken into fibrillæ, forming the interrupted striæ.
   c, c. Muscular filaments forming a tasselled extremity to the fibre.
   d, d. Filaments retaining slight marking of the striæ.

Fig. 4. Circular striæ varying in size on the same fibre.

Fig. 5. *a, a.* Filaments; globules of blood floating behind them, showing their relative diameters.

Fig. 6. Globules magnified 600 times.

PLATE XVIII.

Fig. 1. *a.* A tube cut open longitudinally, magnified 400 times, linear.
   b. General arrangement of fibres, magnified 200 times, linear.

Fig. 2. Muscular fibre of organic life from the trachea of a Horse, showing the tubular character of the filaments.

Fig. 3. Muscular fibre of organic life (Jejunum).

Fig. 4. *a* and *b.* Tendon; tendon of Pectoralis major muscle.

Fig. 1.

Fig. 2.

Fig. 5.

Fig. 3.

Fig. 4.

a

*Fig. 1.*

b

Fig. 2.

Fig. 3.

Fig. 5.

Fig. 4.

a

b
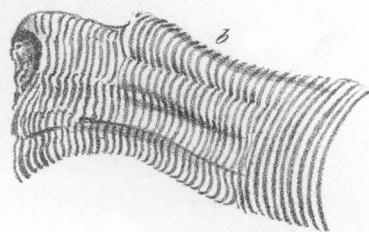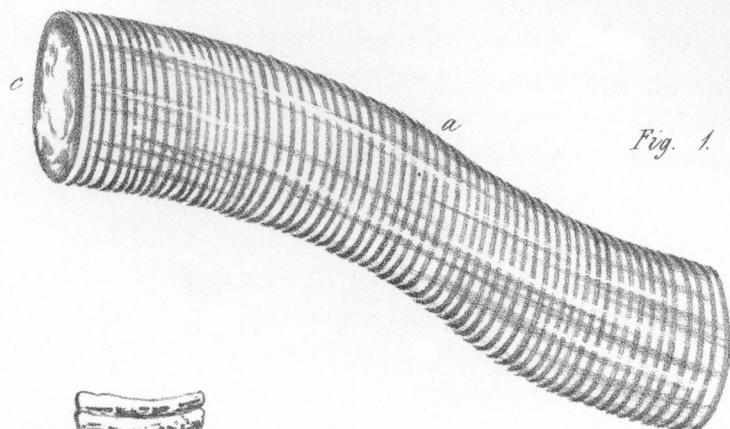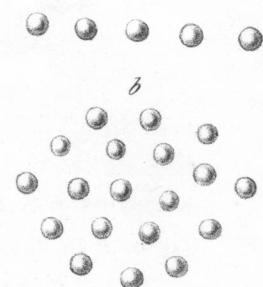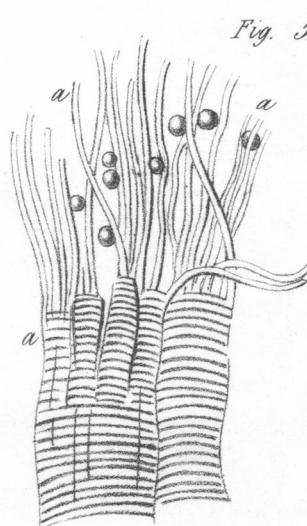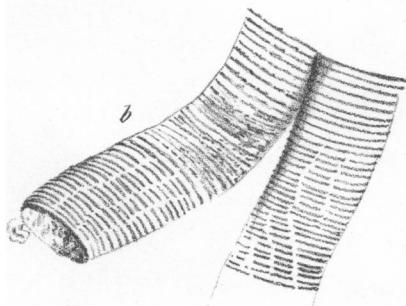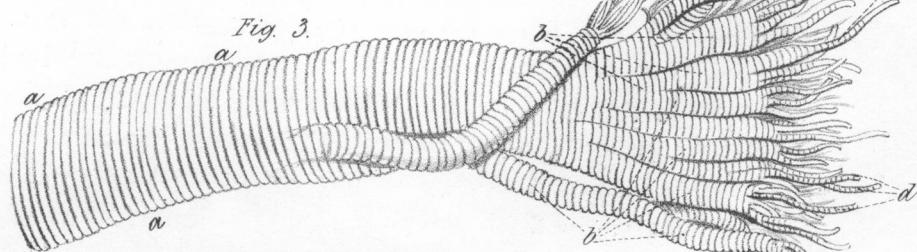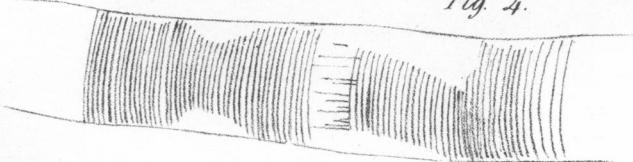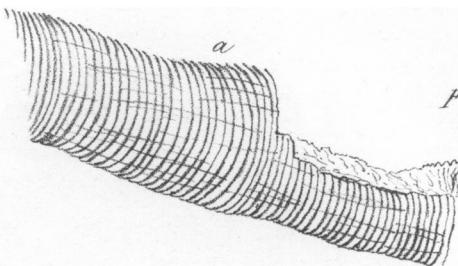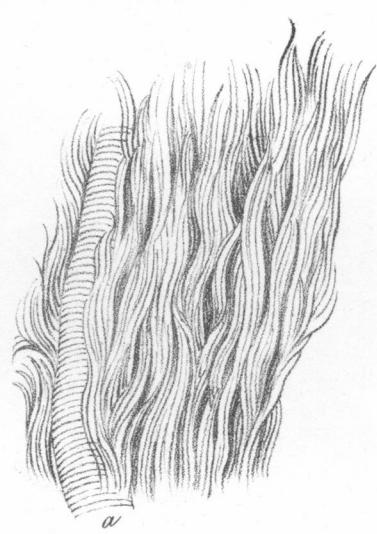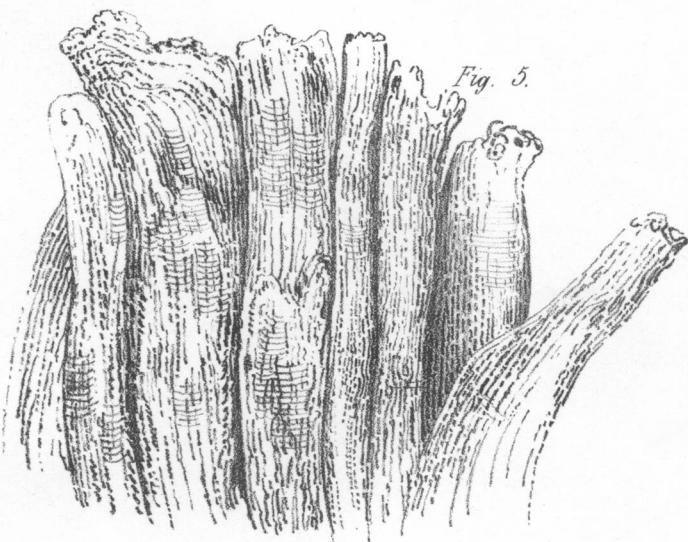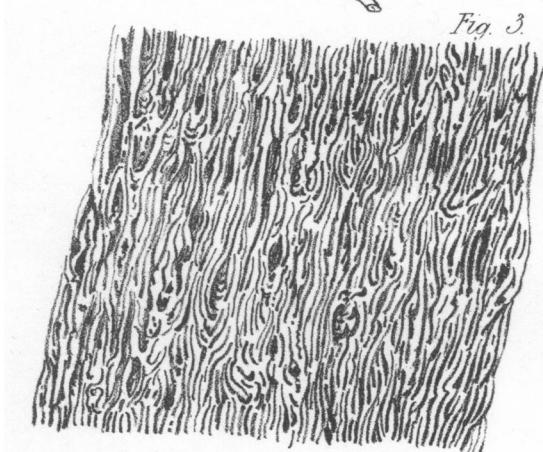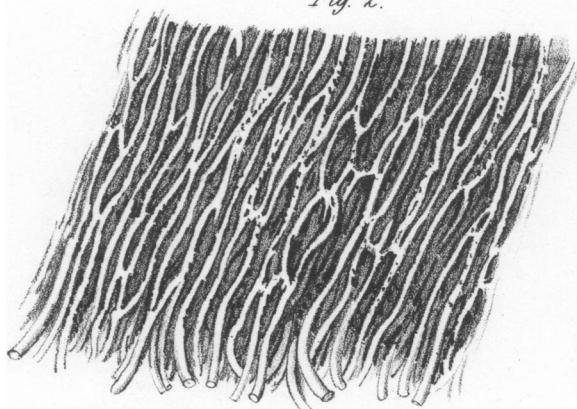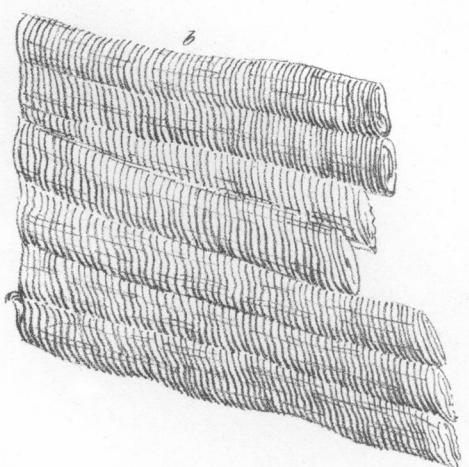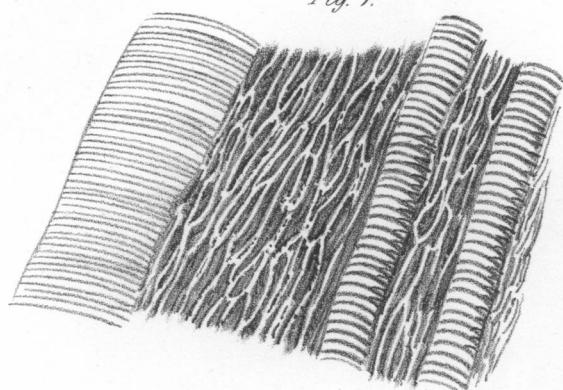
Fig. 1.

Fig. 2.
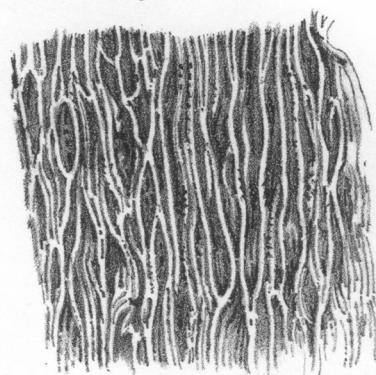
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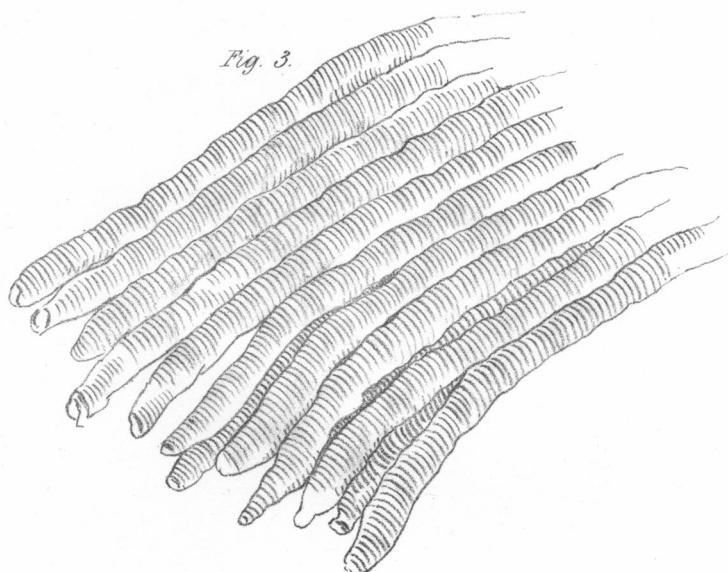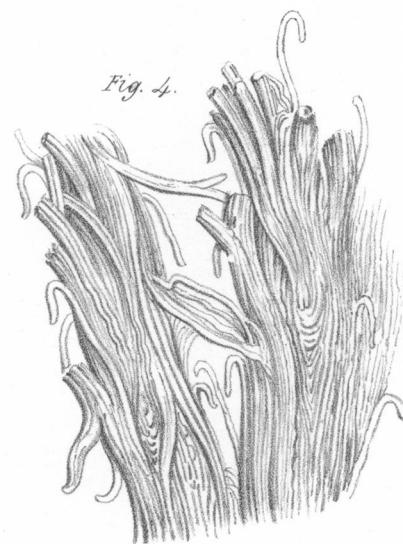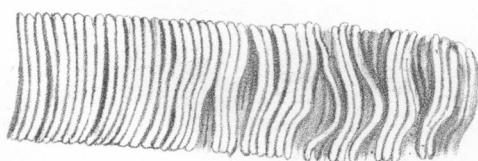
Fig. 4.

Fig. 5.

Fig. 6.
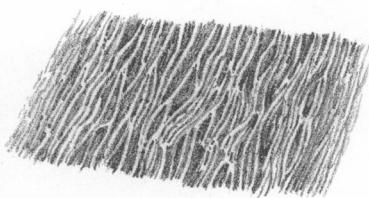
Fig. 4. *b.* Tendon of Tensor tympani muscle, with a single muscular fibre.

Fig. 5. Heart (human), composed of distinct fibres, with a few circular striæ.

PLATE XIX.

Fig. 1. Muscular fibre taken from the human œsophagus, about three inches below the pharynx, showing the two structures of animal and organic life combined.

Fig. 2. Middle coat of an artery.

Fig. 3. Fœtal fibre of animal life, magnified 300 times, linear.

Fig. 4. Ligamentum nuchæ of the Sheep.

Fig. 5. A fibre of animal life torn longitudinally, exhibiting the separations of the dark striæ, the serrated margins being due to the elevations of the light striæ.

Fig. 6. Middle coat of an artery.